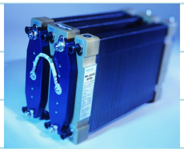
making fuel cells a commercial reality





Outline

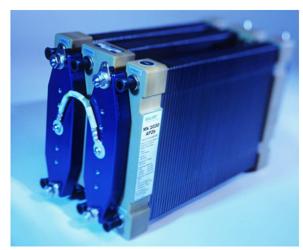
BALLARD®

- Introduction to Ballard
- Commercialization Timelines
- Why Fuel Cells
- Technology "Roadmap"
- Testing Capability
- Fleet Experience
- Automotive Path to Commercialization
- Manufacturing Capability
- Summary

Ballard Power Systems

- World-leading proton exchange membrane fuel cell design, development, manufacture and sale
- Fuel cell focus with strong development and funding partners and a lead customer “go to market” strategy
- ~975 granted and pending patent applications worldwide
- ~600 employees
- $53.7 million revenue in 2005
- Solid financial position with $213 million in cash and cash equivalents

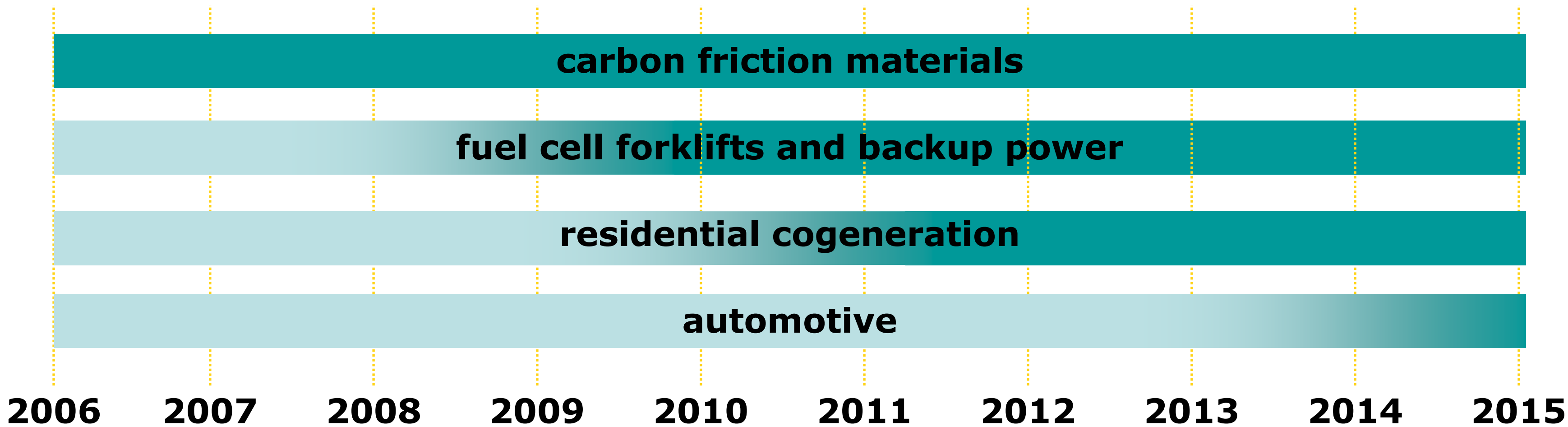



Focused on Near and Long-Term Commercial Markets

BALLARD®

Ballard's products and services include: fuel cells & components, field service & parts and engineering services



market commercialization timeline based on Ballard projections

pre-commercial, positive gross margin sales

commercial sales

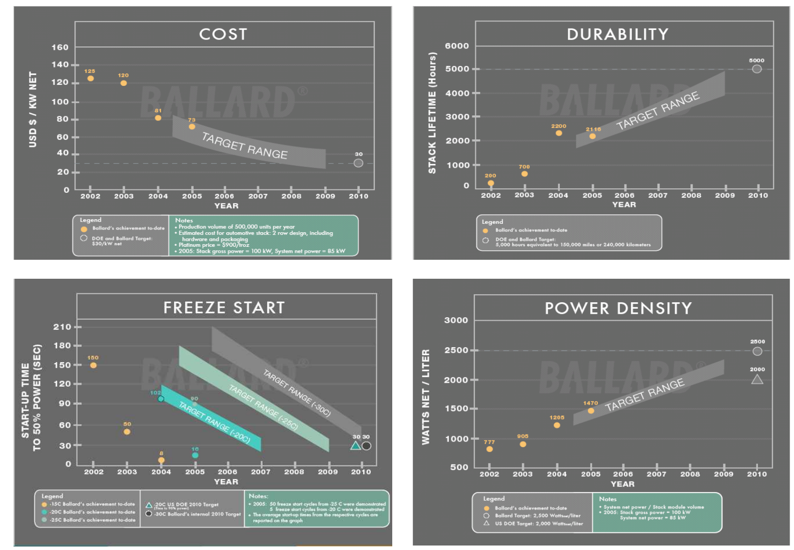
Fuel Cells – the Best Long-Term Solution

Desired Characteristics	Fuel Cells	BEV	ICE Hybrids: Hydrogen Hybrid	ICE Hybrids: Pluggable Hybrid	ICE Hybrids: Diesel Hybrid	ICE Hybrids: Gasoline Hybrid	Biofuel ICE	Conventional ICE (Baseline)
Vehicle Emissions ↓	**Zero**	Zer						
Well-to-Wheels GHG Emissions ↓	**Zero** - High (H2 source dependant)	Zero - High depend						
Max Efficiency (Tank-to-Wheel) ↑	**High**: >50%	Medium						
Well-to-Wheels Energy Efficiency ↑	Low-**High** (H2 source dependant)	Low – High nd						
Fuel Flexibility ↑	**High**	Medi						
Vehicle Range ↑	Medium – high (advances in H2 storage required)	Low						
Reliability ↑	**High** – No Moving Parts	Potentially No Movin						
Cost ↓	Low – medium Expected to compete with ICE	High – Expected low volume production	Medium	Medium	Medium	Medium	Medium	Low

- *Fuel cells the most comprehensive solution to energy & environmental challenges: air quality, greenhouse gases and energy security*
- *Fuel cells and batteries complementary, not competing technologies.*
- *Unlike ICE hybrids, fuel cell hybrids enable **pure electric** drive trains.*
- *Hybridization accelerates commercial introduction of fuel cell vehicles.*

Technology "Road Map" Summary

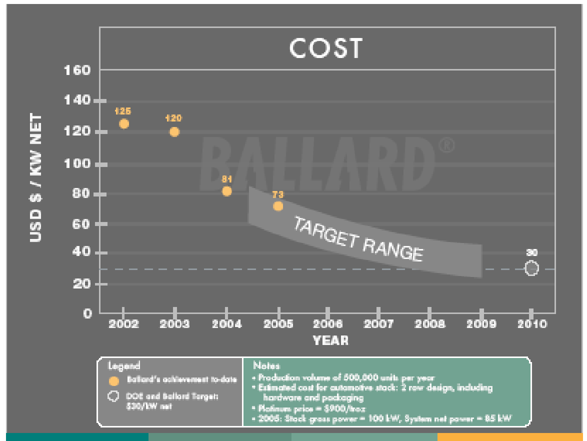
- Technology "Road Map" is Ballard's commitment to demonstrate commercially-viable automotive fuel cell technology by 2010
- Cost and durability are the biggest barriers remaining
- Detailed plans and organizational capabilities in place



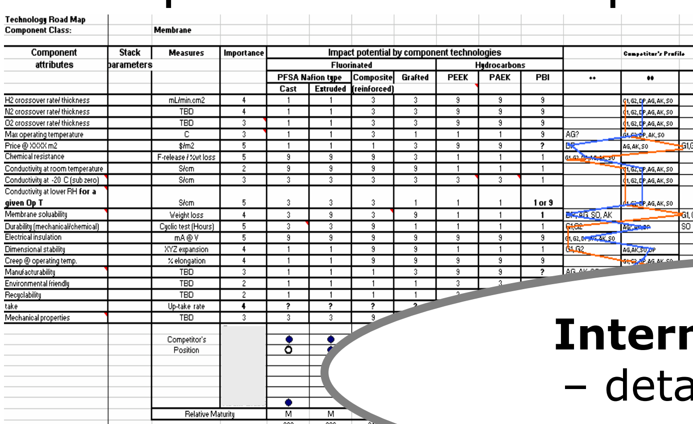
	2005 Achievement	2006 Goal	2010 Target
Cost	$73/kW	$65/kW	$30/kW
Freeze Start	-25ºC in 90 seconds	-30ºC in 195 seconds	-30ºC in 30 seconds
Power Density	1,470 Watts/$L_{(net)}$	1,500 Watts/$L_{(net)}$	2,500 Watts/$L_{(net)}$
Durability	2,100 hours	2,300 hours	5,000 hours

Technology Planning supporting "Road Map"

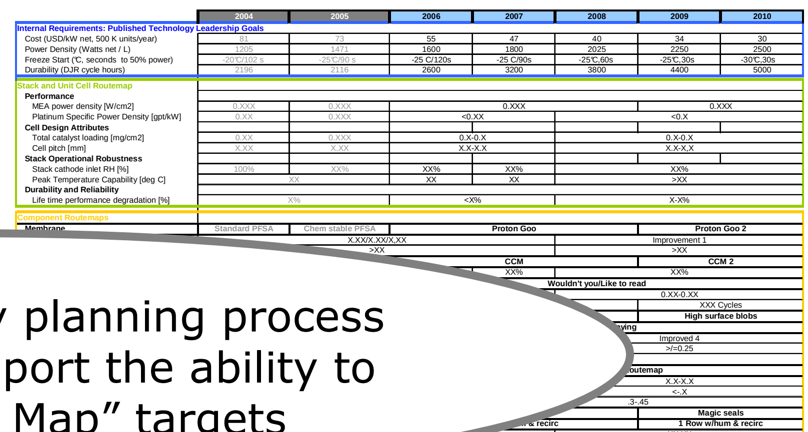
External communication tool – **technology** progress



Component Routemap



Stack Routemap



Internal technology planning process – detailed plans support the ability to meet the "Road Map" targets

Cost Reduction: Catalyst Technology Advancements

BALLARD®

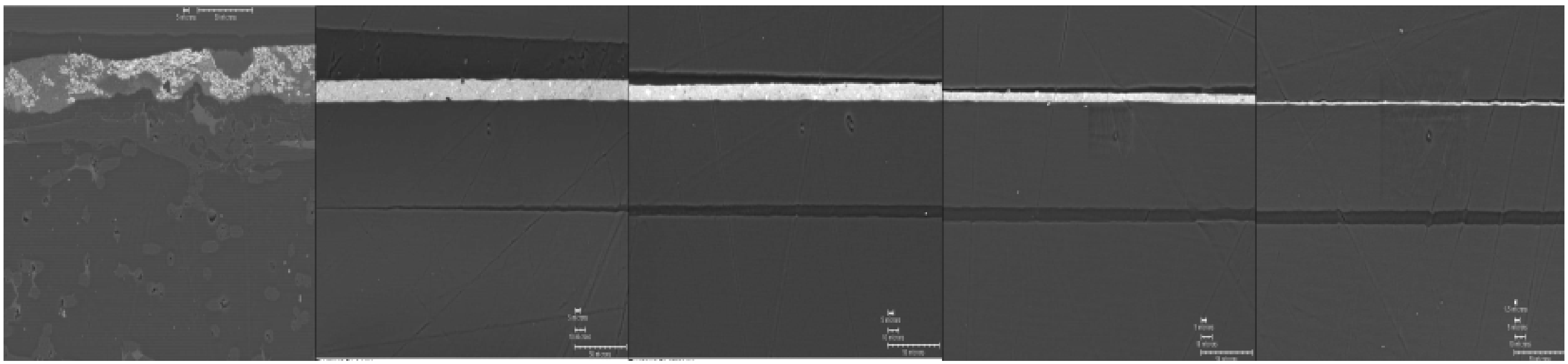
	1994	2004	Already Lab Demonstrated	>2010
Platinum	8-10 mg/cm²	1.0 mg/cm²	0.3-0.5 mg/cm²	0.3 mg/cm²
Processes	hand coating	screen printing spraying	roll coating (knife, comma bar)	roll coating / CVD nanoparticle dispersion
Catalyst Structure	No catalyst support	Carbon Support	Carbon Support	Corrosion-free Support
	Pt Metal	Pt and Pt alloys	Pt and Pt alloys	Non-PGM or low Pt content alloys

Continuous Processing & Cost Reduction

BALLARD®

Catalyst Reduction

– Tight control of catalyst loading and layer thickness



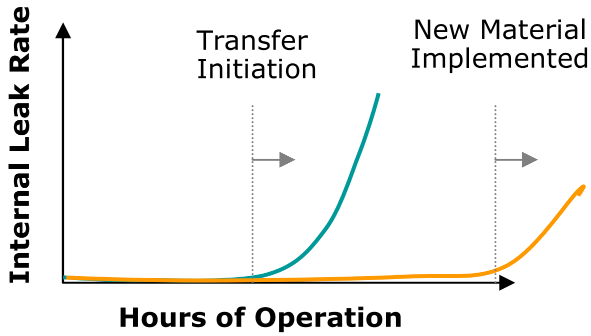
25 um 10 8 5 1.5

Durability: Failure Mode Understanding and Mitigation

BALLARD®

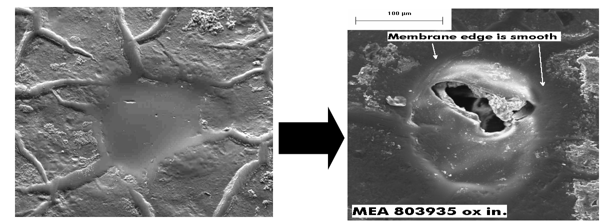
Internal Transfer Development – Peroxide Radical Attack on Perfluoroionomers

OBSERVATION OF FAILURE MODE



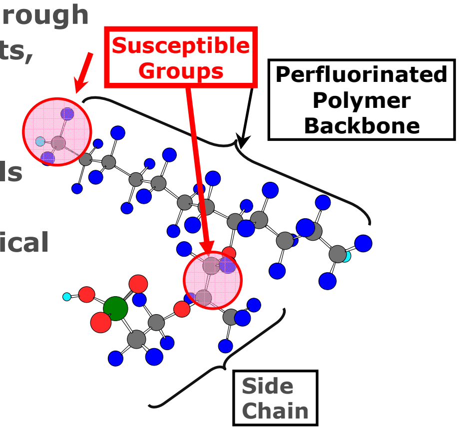
Thinning

Rupture

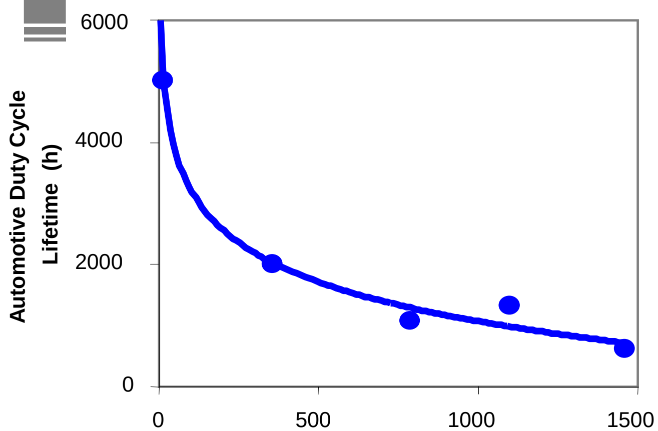


FAILURE ANALYSIS

1. Peroxide generation in fuel cell
2. Peroxide radical production through reaction with Fenton's catalysts, such as iron (Fe^{2+})
3. Attack of membrane by radicals resulting in loss of material (thinning) and loss of mechanical strength
4. Rupture of membrane due to mechanical stresses



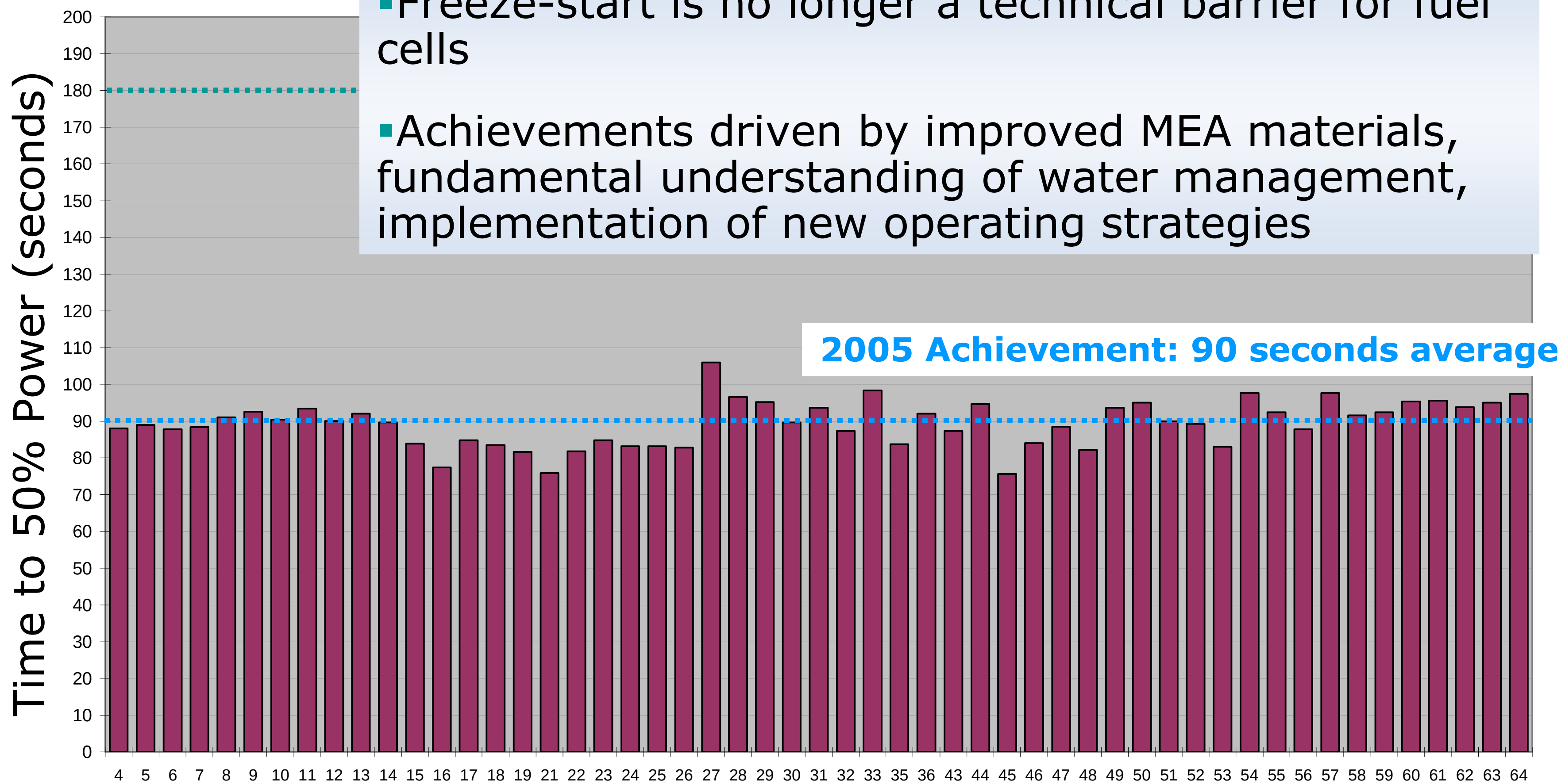
FUNDAMENTAL UNDERSTANDING



ACCELERATED STRESS TESTS

2005: Freeze Start from –25 °C (Time to 50% Power)

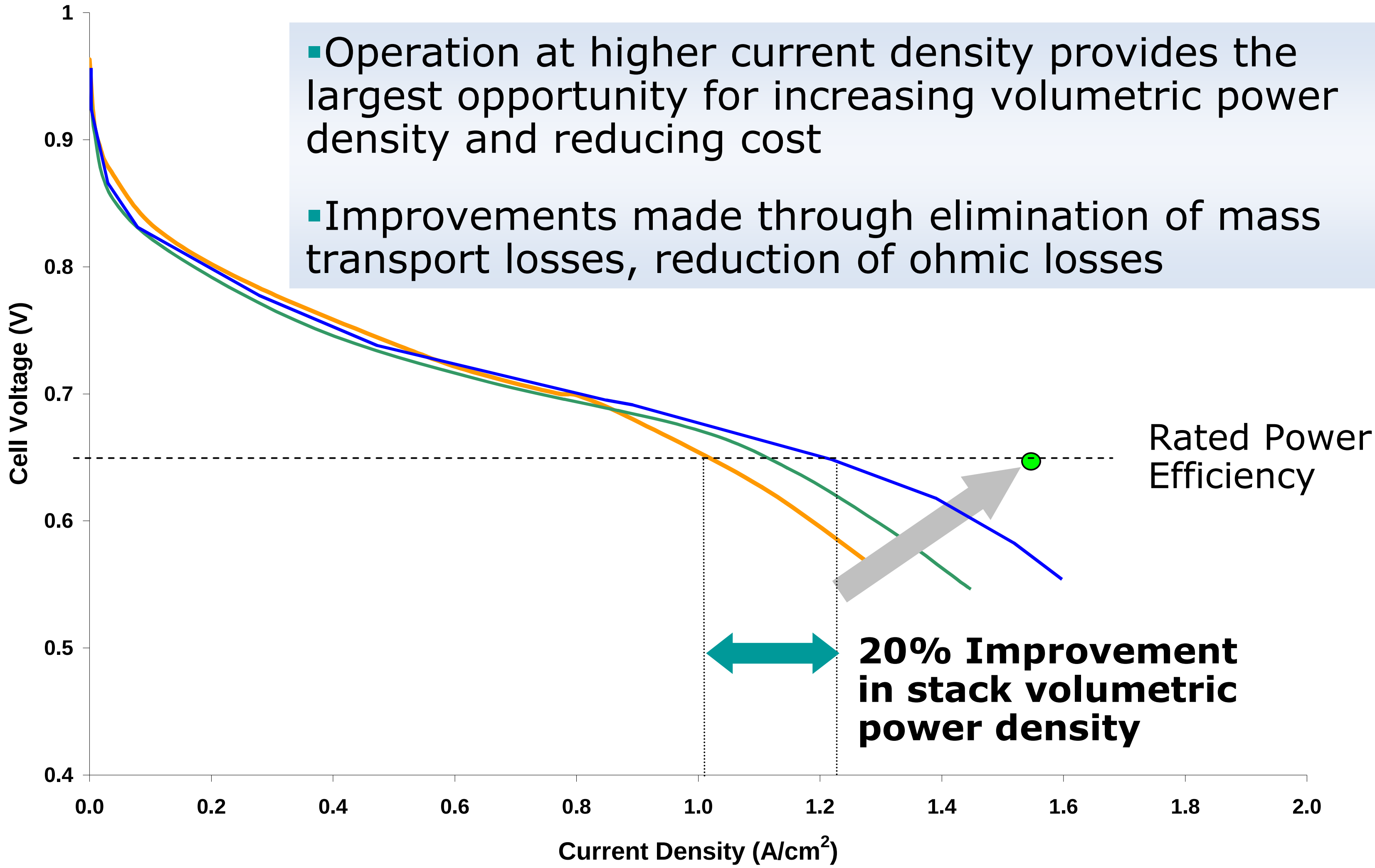
- Freeze-start is no longer a technical barrier for fuel cells
- Achievements driven by improved MEA materials, fundamental understanding of water management, implementation of new operating strategies



Power Density

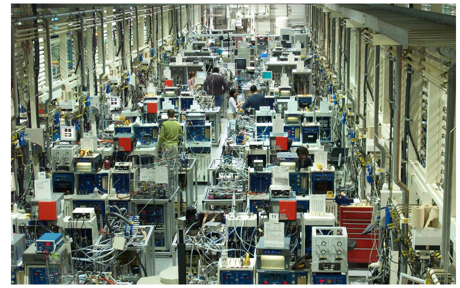
Polarization Curve Improvements

- Operation at higher current density provides the largest opportunity for increasing volumetric power density and reducing cost
- Improvements made through elimination of mass transport losses, reduction of ohmic losses

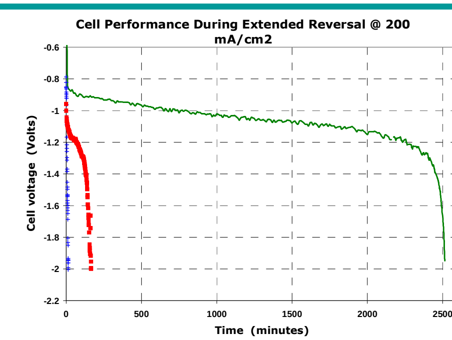


Fuel Cell Test Facility

- World’s largest test facility dedicated to fuel cell testing and research with more than 100 test stations
- 400,000 hours+ of tests/year
- Units from < 100 W to 250 kW
- Test capability from –40°F to +140°F
- Three fully equipped failure analysis labs
- Integrated data collection and reporting
- Specialized Accelerated Stress Test (AST) equipment and protocols
- Advanced development testing tools



Test Lab



AST Results

Diagnostics – Current Mapping

BALLARD

Real World Experience to Advance Technology

- 130+ vehicles
- 24 cities
- 5 million passengers
- real world data

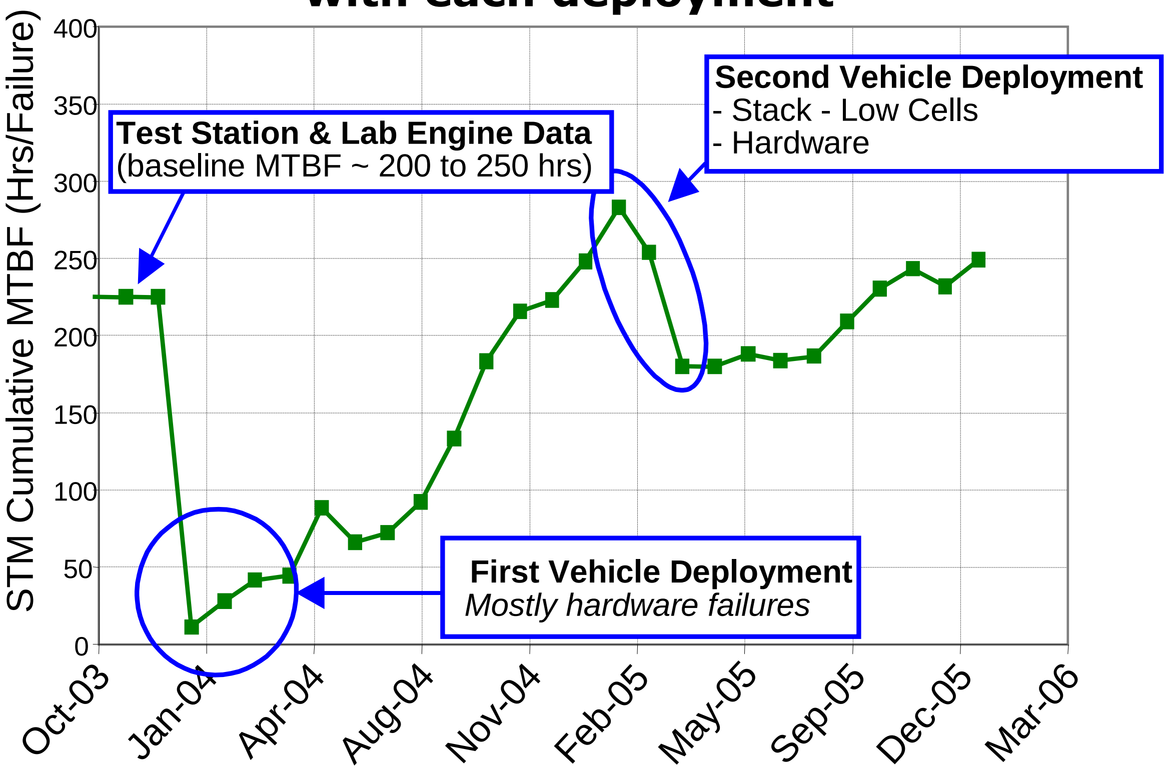
Vehicles powered by Ballard fuel cells have logged 2 million miles

Fuel Cell Fleets – Result in Reliability Growth and Technology Advancement

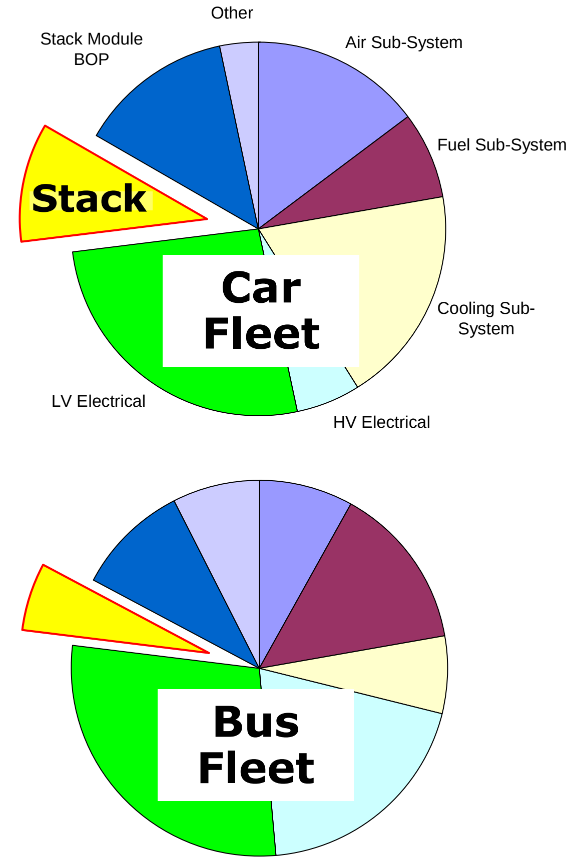
BALLARD®

Fuel Cell Stack Module Reliability Growth

New failure modes & lessons learned with each deployment



Majority of field failures are non-stack related



Automotive Path to Commercialization

BALLARD

Fleet	**2005-2008**	**2009-2011**	**2012-2014**	**2015-2018**
Technology	**2001**	**2005**	**2008**	**2010**

Technology Demonstration

Mk902

Customer Acceptance

Mk1100

Cost Reduction

Market Introduction

Key attribute improvements of each generation

- Durability
- Power density
- Cost reduction
- Freeze / thaw

- Power density
- Durability
- Robustness
- Freeze start (-15ºC)
- Design for manufacture

- Cost reduction
- Power density
- Durability
- Robustness
- Freeze start (–25ºC)
- Design for manufacture

- Cost reduction
- Reliability

Manufacturing Capability

Fuel Cell Manufacturing Plant:

- Automotive certified supplier
- Installed capacity to meet CARB ZEV requirements of our customers through 2011
- Production quality prototypes, advanced process development
- Capacity will be added to manufacture volumes beyond 2012

Summary

BALLARD®

- Fuel cells offer the best long-term alternative to the ICE
- Ballard has the R&D, product development, manufacturing, and financial strength to make fuel cells a commercial reality
- Ballard's published Technology "Road Map" is our public commitment to demonstrating commercially viable automotive fuel cell technology by 2010
- Ballard's partners have put 130 fuel cell vehicles on the road in 24 cities world-wide, significantly advancing the technology and proving the viability through real world usage
- Development of the next generation automotive fuel cell, the Mk1100, is on track

The ZEV mandate is an important driver for technology development and market adoption